Document Title: **Frequency Stability for FCC Requirements**

Design tested: **VitalSense Transmitter**

Date written: **September 26, 2003**

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Purpose of investigation: **Verify that the transmitter meets FCC frequency stability requirements.**

1.0 SUMMARY DESCRIPTION

The capsule and patch transmitter circuits were tested to verify they meet FCC frequency stability requirements as outlined in 47CFR15.229. Under paragraph (d) of 15.229, the carrier frequency must not drift more than ±0.01% or ±100ppm over the temperature range of –20degC to 50degC.

2.0 DESIGNS TESTED

- Frequency stability of capsule transmitter
- Frequency stability of patch transmitter.

3.0 TEST SETUP

Test Equipment:

Spectrum Analyzer (HP8594E)
Prototype receiver antenna.
Alcohol/water bath capable of cooling (Julabo FP 45)
Water bath capable of heating (Julabo model 27).
Precision laboratory thermometer (Instrulab model 4202C-27-14)
Two Capsule Transmitters with modulation disabled.
Two Patch Transmitters with modulation disabled.

Test Setup:

The capsule transmitter and the patch transmitter had very similar test setups. The transmitters were tested in a special test mode which allowed them to continuously transmit. Two transmitters were tested simultaneously; one with a logic 1 applied to the modulation input, and the other with a logic 0 applied to the modulation input. The transmitters were tested over temperature, and then the logic on their data input lines was reversed. The transmitters were tested over temperature again. Since the transmitters have FSK modulation, this tested the frequency stability of the two sidebands. The average of the two sidebands results in the carrier frequency.

The transmitters were cooled using an alcohol/water bath, and were heated using a water bath. The temperature of the water bath was controlled through the use of tanks specifically designed for precision temperature control (Julabo models FP 45 and 27). The temperature was measured by a precision laboratory thermometer (Instrulab model 4202C-27-14). The transmitters were lowered into crucibles filled with mineral oil. The mineral oil allowed better equilibration of temperature from the tank fluid to the transmitters. The transmitters were allowed to equilibrate at a particular temperature for 15 to 20min. before a reading was taken.

The frequency was measured using a prototype receiver antenna and a spectrum analyzer (HP8594E). The results were recorded and graphed using Microsoft Excel.

Figures 1 and 2 show photographs of the test setup.

Both transmitters were tested over their full operating range. The patch transmitter was tested over the range –20degC to 60degC, and the capsule transmitter was tested over the range 20degC to 50degC. The capsule transmitter is intended as an ingestible sensor, and is not likely to see temperatures outside the range 32degC to 42degC.

3.1 TEST RESULTS

Figure 3 shows a graph of the carrier frequency variation over temperature for two patch transmitters. Transmitter 1 (TX1) uses a FOX 325B type crystal as the resonator, and the transmitter 2 (TX2) uses a Golledge GSX-13 type crystal. Each was tuned slightly differently so as not to be exactly 40.68000MHz. Transmitter 1 exhibited a carrier frequency stability of +350Hz, -390Hz or +9ppm, -10ppm over the temperature range of –20degC to 60degC. Transmitter 2 exhibited a carrier frequency stability of +370Hz, -360Hz or +9ppm, -9ppm over the temperature range of –20degC to 60degC. This is well within the required limit of ±100ppm over the temperature range –20degC to 50degC.

Figure 4 shows a graph of the sideband frequency variation over temperature of two capsule transmitters. The capsule transmitter is very similar to the patch transmitter. The patch transmitter has an emitter resistor feedback network which the capsule transmitter does not have. Otherwise, the capsule uses the same Pierce configuration with a crystal resonator. Both capsule transmitters used a GSX-13 crystal. Based on the data gathered from the patch transmitter, there is no reason to believe the sideband stability is not a good representation of the carrier stability. The sideband frequency variation data has been presented here for that reason.

The capsule transmitter #1 data input was tied to logic 1 and transmitter #2 data input was tied to logic 0. The upper sideband exhibited a frequency stability of +320Hz, -240Hz or +8ppm, -6ppm over the full operating temperature range 20degC to 50degC. The lower sideband exhibited a frequency stability of +190Hz, -160Hz or +5ppm, -4ppm over the temperature range 20degC to 50degC. This is also well within the frequency stability required limit of ±100ppm.

The test results have been summarized in Table 1.

Table 1. Summary of frequency stability test results for both patch and capsule type transmitters.

Transmitter	High Limit	Actual positive drift	Pass/Fail
Patch TX #1	+100 ppm	+ 9 ppm	Pass
Patch TX #2	+100 ppm	+ 9 ppm	Pass
Capsule TX #1	+ 100 ppm	+ 8 ppm	Pass

Transmitter	Low Limit	Actual negative drift	Pass/Fail
Patch TX #1	- 100 ppm	- 10 ppm	Pass
Patch TX #2	- 100 ppm	- 9 ppm	Pass
Capsule TX #1	- 100 ppm	- 6 ppm	Pass

4.0 CONCLUSIONS

Both the patch-type transmitter and the capsule-type transmitter of the VitalSense system were tested for transmitted frequency stability over temperature variations. The patch transmitter exhibited a frequency stability of +9pppm, -10ppm over the full operating temperature range. The capsule transmitter exhibited a frequency stability of +8pppm, -6ppm over the full operating temperature range. Both transmitter types have frequency stability well within the required limit defined by 47CFR15.229 paragraph (d).

5.0 FIGURES

Figure 1. Photograph 1 of frequency stability test setup.

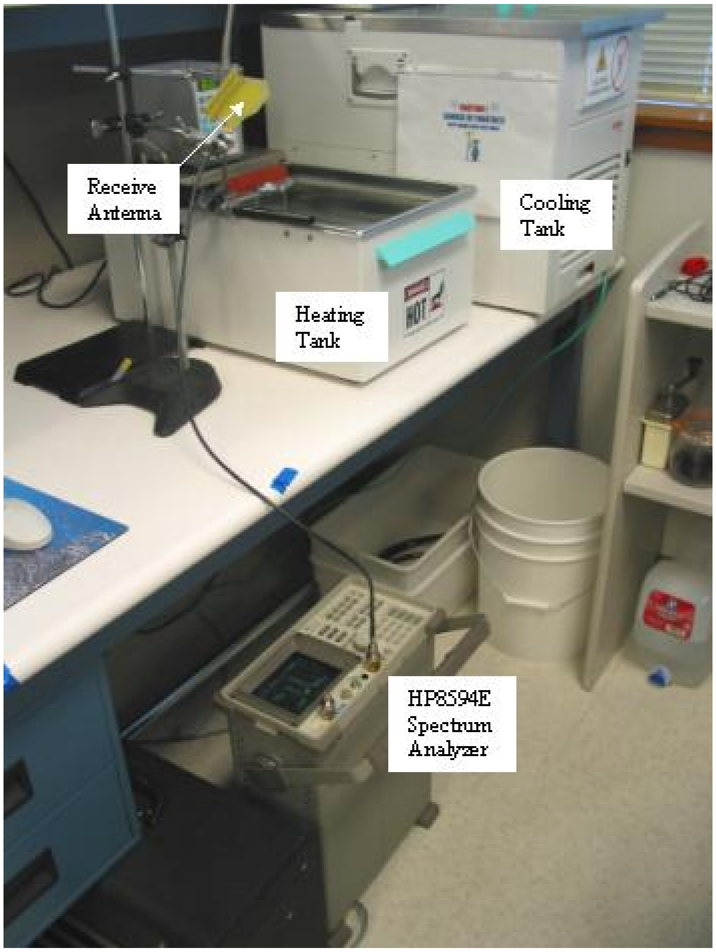

Figure 2. Photograph 2 of frequency stability test setup.

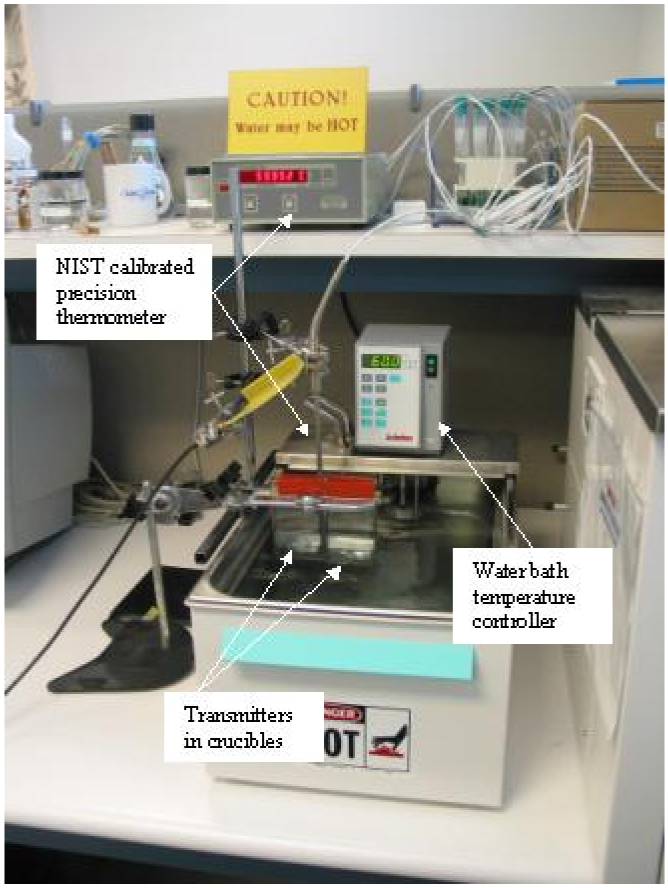

Figure 3. Frequency stability of patch transmitter carrier frequency over full operating temperature range.

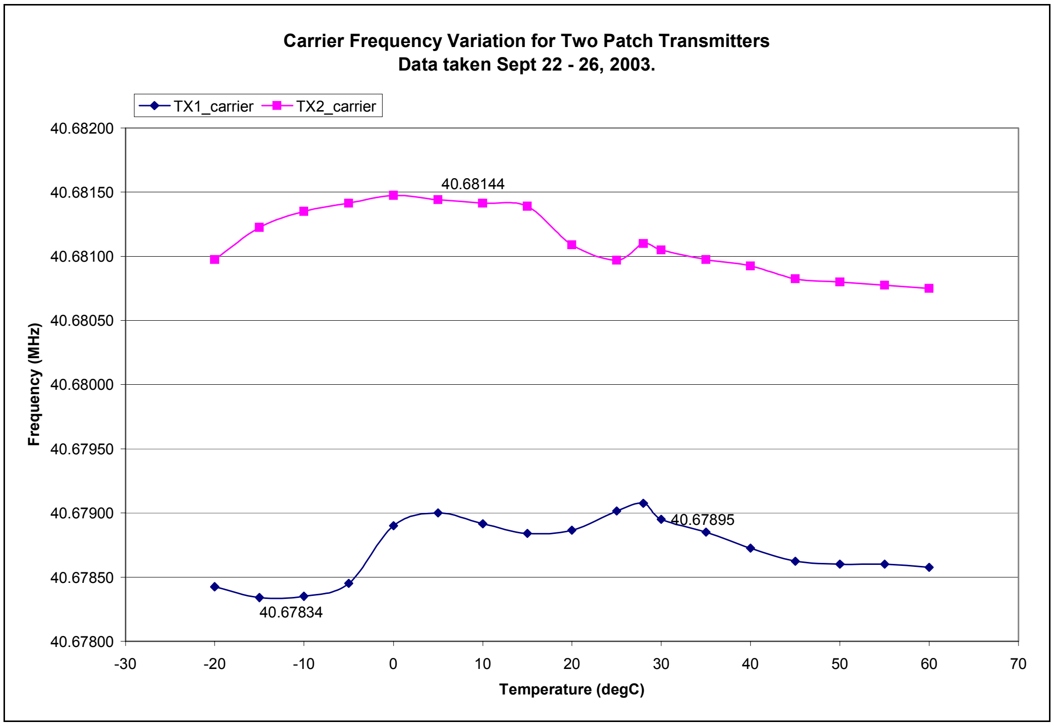

Figure 4. Frequency stability of capsule transmitter over full operating temperature range.